3D Metal Printer

Vandal Forge – Senior Design 2016-2017

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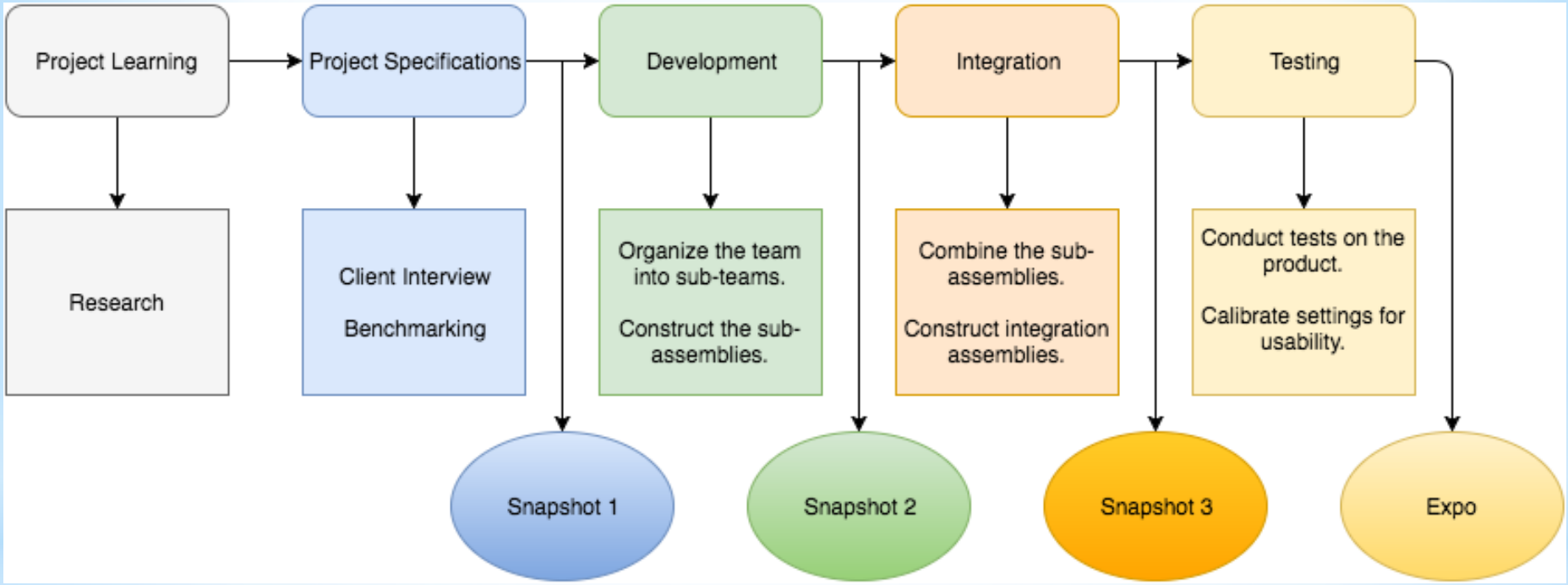
Problem Statement

* Additive Manufacturing > Conventional Methods
* 3D Plastic Printers are everywhere and cheap.
* 3D Metal Printers are expensive.

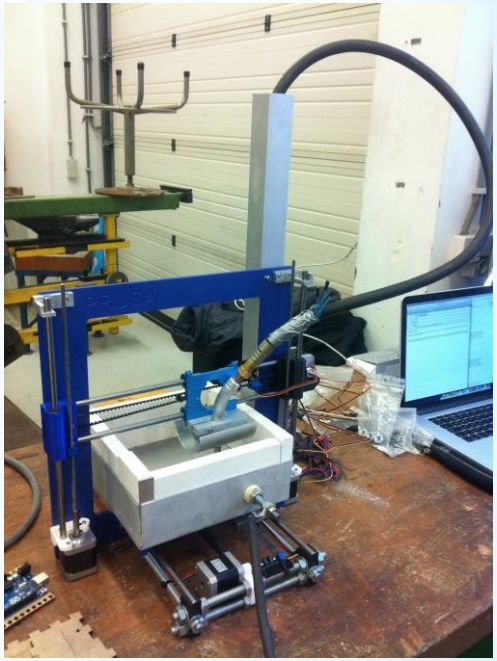
Mission Statement

* Develop an inexpensive 3D metal printer using MIG welder technology in order to bring 3D metal printing to academia and the home user.

Design Process



Project Learning



University of Michigan

* Delta Style Printer
* Under $1500
* Open Source

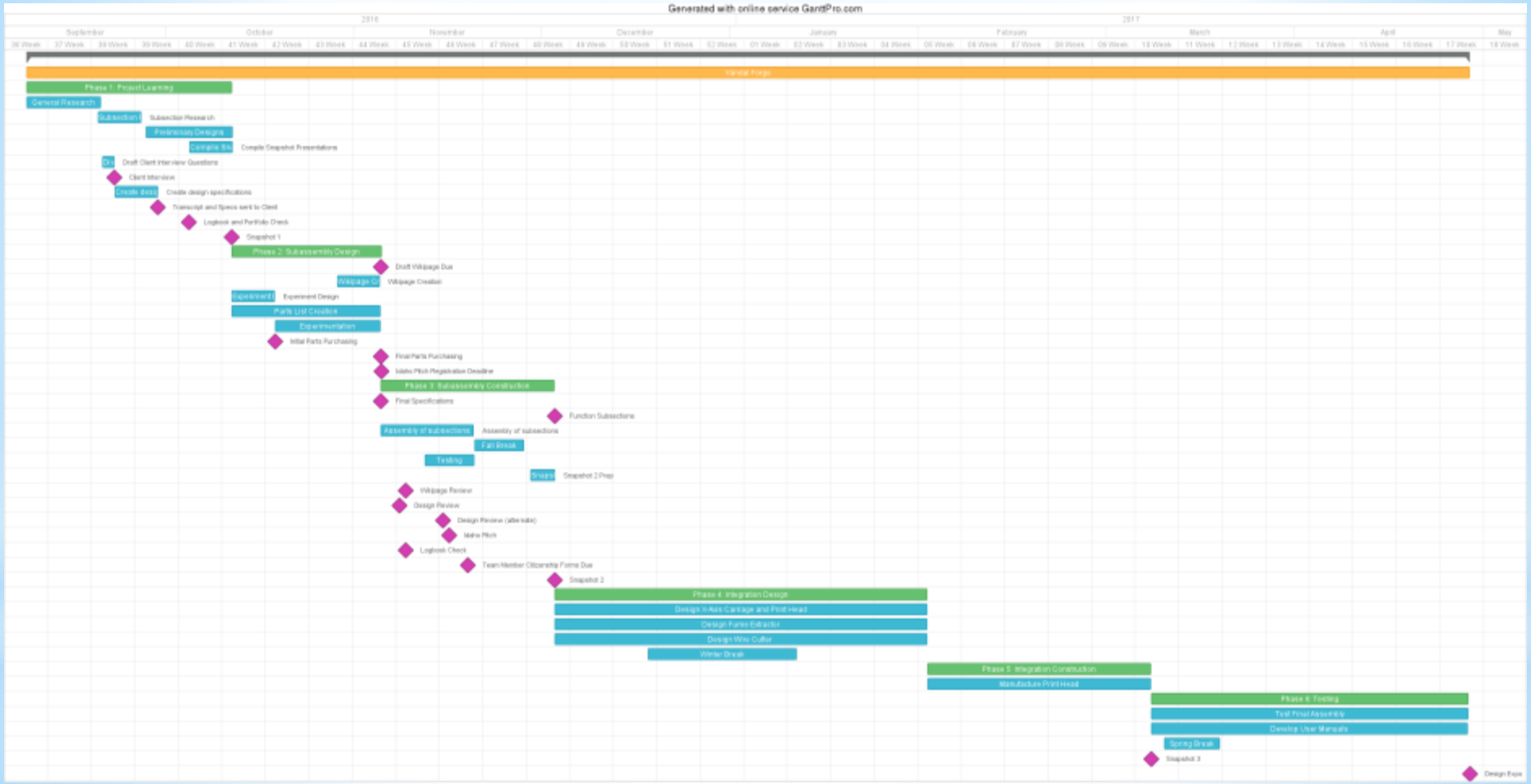
Delft University of Technology

* Prusa 3-Axis Printer
* Open Source
* Inexpensive

Project Specifications

#	Needs	Metric	Impact	Units	Marginal Value	Ideal Value	Final Value
1	13,14	Print Volume	5	in^2	8x8x7	12x8x7	9.84x8.3x8
2	5,16	Accuracy/Resolution	5	mm	150% of Electrode Size	125% of Electrode Size	150% of Electrode Size
3	7,16	Print Speed	5	mm/s	100-200	200-450	~330
4	4	Electrode Size	4	in	0.025	0.02	0.023
5	2	Area Plate Thickness	3	in	1/8 1/16	0.0079	1/8 1/16
6	8	Input Voltage	3	volts	120	120	120
7	12	Exterior Temperature	5	°F	110	100	100
8	15	Cost	5	$	$1,500.00	<1000	$1,500-$2,000
9	14	Total Size	4	in	36x36x36	24x24x24	24x36x24
10	4	Layer Thickness	4	mm	25% of Electrode Size	50% of Electrode Size	25% of Electrode Size
11	5,6	Wire Feed Rate	3	ipm	40-500	40-700	~157
12	2	Output Amperage	4	amps	10-50	7-30	30-60

Project Schedule

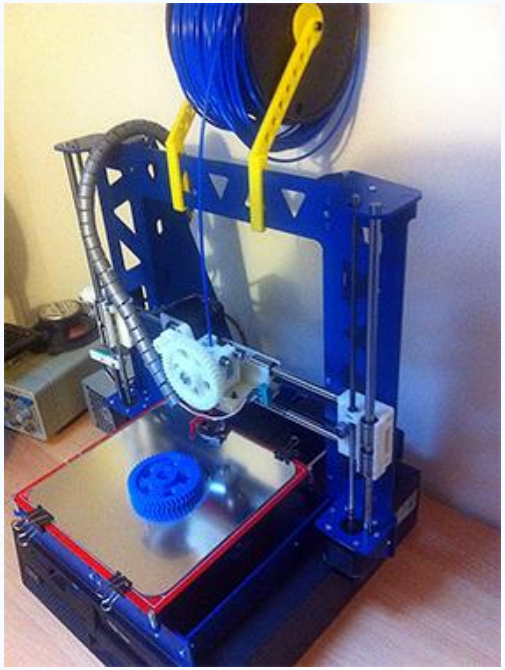


Bill of Materials

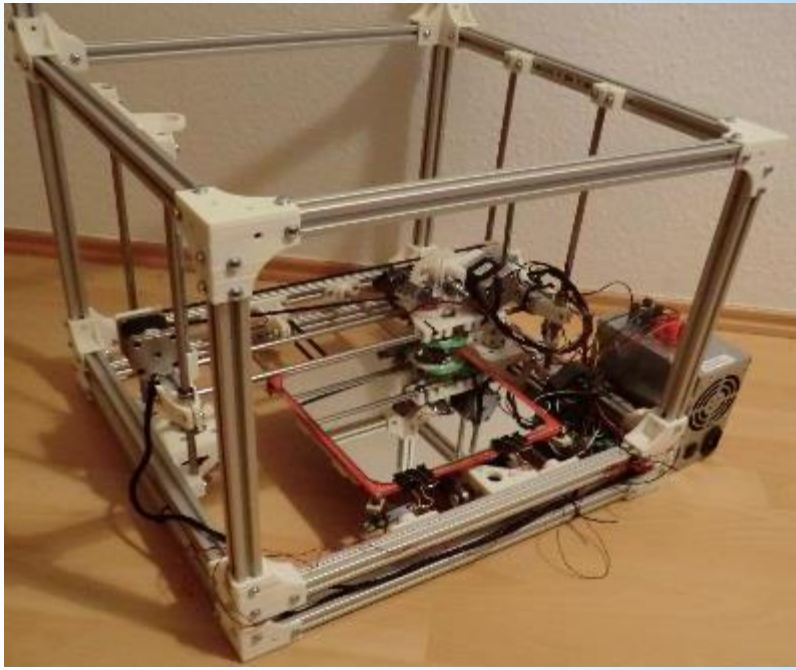
Assembly	Sub-Assembly	Part	Quantity	Owner	Cost	Purchase Location	Function
CNC	X-Axis	GT2 Pulleys	1	CNC Team	$9.59	https://www.amazon.com/Aluminum-Pulley-RepRap-3D-pr	
		GT2 Belt	1		$9.59	https://www.amazon.com/Aluminum-Pulley-RepRap-3D-pr	
		NEMA 17 Stepper Motor	1		$14.99	https://www.amazon.com/Stepper-Motor-Bipolar-4-lead-P	
		Axial Bearings	1		$0.00	Donated	
		385mm Smooth Rod	2		$18.83	https://www.amazon.com/gp/product/B017SH7YVA/ref=s	
		Linear Bearings	3		$15.88	https://www.amazon.com/6pcs-LM8UU-Linear-Bearing-Bu	
	Y-Axis	GT2 Pulleys	1		$9.59	https://www.amazon.com/Aluminum-Pulley-RepRap-3D-pr	
		GT2 Belt	1		$9.59	https://www.amazon.com/Aluminum-Pulley-RepRap-3D-pr	
		Linear Bearings	3		$15.88	https://www.amazon.com/6pcs-LM8UU-Linear-Bearing-Bu	
		Axial Bearings	1		$0.00	Donated	
		350mm Smooth Rod	2		$18.83	https://www.amazon.com/gp/product/B017SH7YVA/ref=s	
		NEMA 17 Stepper Motor	1		$14.99	https://www.amazon.com/Stepper-Motor-Bipolar-4-lead-P	
	Z-Axis	Lead Screw	2		$5.14	http://www.mcmaster.com/#acme-threaded-rods/=14nob	
		Linear Bearings	4		$15.88	https://www.amazon.com/6pcs-LM8UU-Linear-Bearing-Bu	
		330mm Smooth Rod	2		$18.83	https://www.amazon.com/gp/product/B017SH7YVA/ref=s	
		NEMA 17 Stepper Motor	2		$29.98	https://www.amazon.com/Stepper-Motor-Bipolar-4-lead-P	
	Frame (Prusai3steel)		1		$84.07	http://orballoprinting.com/en/frame/8-prusa-i3-steel-fram	
	Wire Drive	Spool Pivot	1	Matt			
		Spool Tensioner	1	Matt			
		Wire Drive Assembly	1	Matt	$24.90	https://www.amazon.com/GOCHANGE-Welder-Welding-M	
		Aluminum Rollers	2	Matt			
	Power Supply			Kyle			
Welder	Hose/Cable	Gas Hose	2	Max			
		Gas Hose Fittings		Max			
		Wire Hose	1	Max			
		Wire Hose Fittings		Max			
		Electrical Cable	1	Max			
	Gas	CO2 Gas Tank	1	Max			
		Argon Gas Tank	1	Max			
		Tank Regulators	2	Max			
		Electronic Valves	2	Max			
	Print Head (X-Axis Carriage)			Matt			
	Wire Cutter			Nathan			
Integration	Controls	Control Board (SmoothieBoard)	1	Jay	$162.97	https://shop.uberclock.com/collections/smoothie/product	
	Sensors			Kyle			
	Shield Case	Extruded Aluminum Frame	1	Matt			
		Shade Lens	3	Matt			
	Fume Extractor		5	Matt			

CNC

Prusa i3
+ Very Common
+ Simple
+ Reliable
+ Lots of online support
- Lots of plastic parts
- Vibration-prone
- Rubber Belts



P3Steel
+ Simple
+ Reliable
+ Stable
+ Few plastic parts
- Rubber Belts
- Heavier

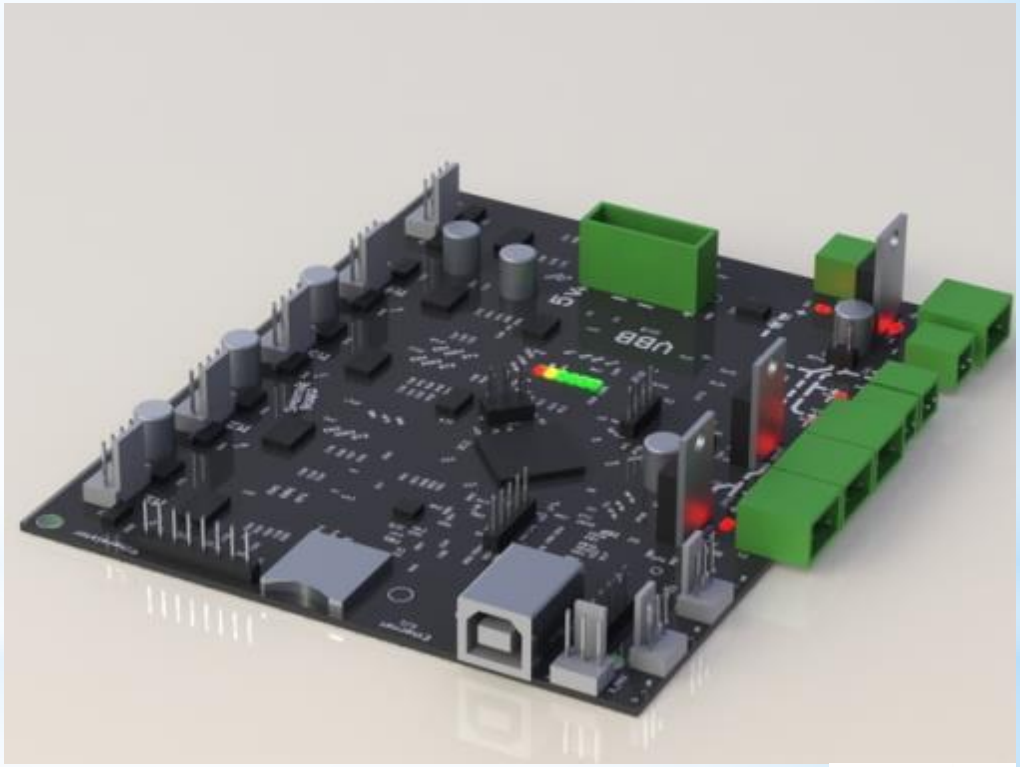


Haeckel
+ Stable
+ Easy to enclose
- Little to no documentation
- Lots of plastic parts
- Expensive
- Complex

Controller

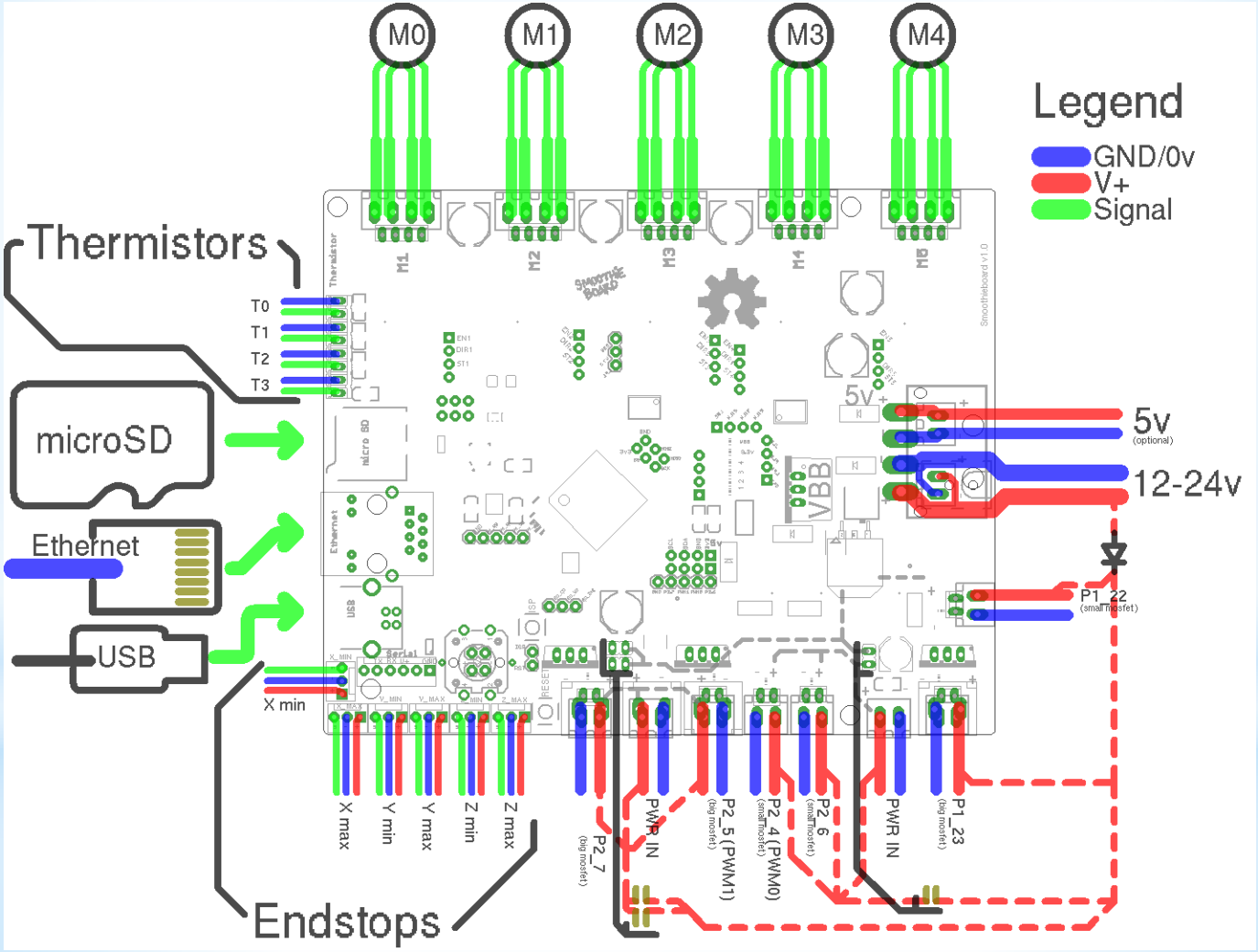
PCB	SmoothieBoard
MCU Included	Yes
Bits	32
CPU	ARM-Cortex M3 LPC1769
CPU MHz	120
Stepper Motor Connections	5
Stepper Motor Drivers Included	Yes
Endstop Inputs	6
Power	12/24 V
External Fan Support	Yes
MicroSD	Yes
Interfaces	SPI, I2C, PWM, DAC, Ethernet, GPIO
LCD Support	Yes
Debugging Support	GDB

Smoothieboard

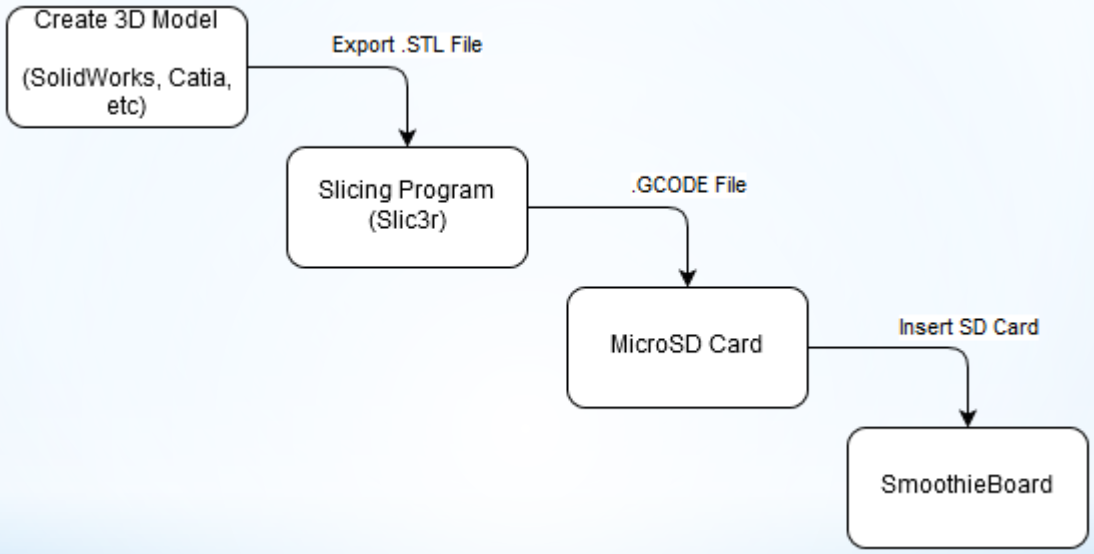


KICKSTARTER

Controller


M0
M1
M2
M3
M4
Legend
GND/0v
V+
Signal
Thermistors
T0
T1
T2
T3
microSD
Ethernet
USB
X min
Endstops
5v
(optional)
12-24v
P1_22
(small mosfet)
X max
Y min
Y max
Z min
Z max
P2_7
(big mosfet)
PWR IN
P2_5 (PWM1)
(big mosfet)
P2_4 (PWM0)
(small mosfet)
P2_6
(small mosfet)
PWR IN
P1_23
(big mosfet)

Workflow Process



Power Supply

Specifications:

Input Voltage: 115VAC

Output Voltage: 1-18V

Output Current: 0-80A

Power Supply

Option 1: Buy a Welder for Power Supply

Pros:
- Inexpensive
- Meets Specifications
- Reliable

Cons:
- No Voltage Control

Option 2: Use Off-The-Shelf Power Supplies

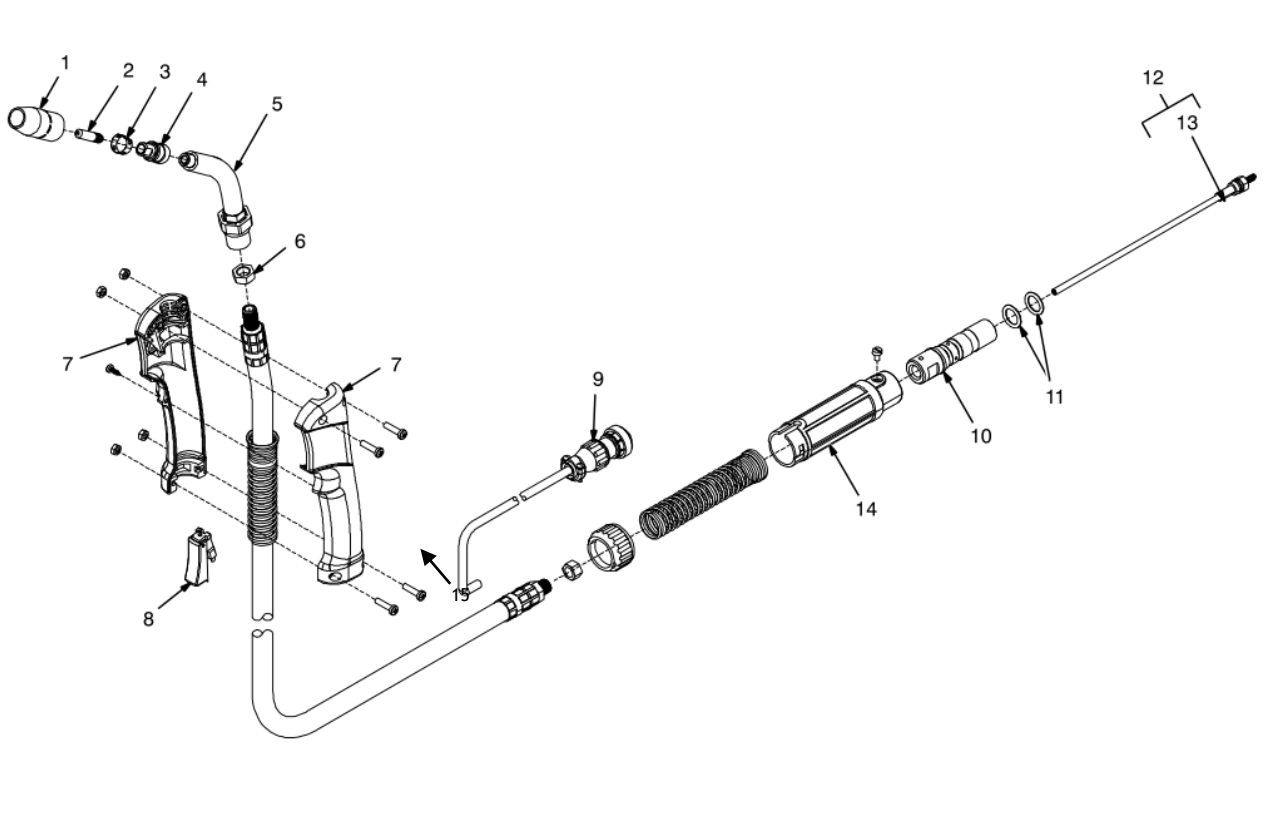
Pros:
- More Controllable

Cons:
- Not Reliable
- Protection
- Not Designed for Welding

Gas System

Parts Needed:
1- Nozzle
2- Contact Tip
4- Gas Diffuser
12- Gun Liner
15- Gun Cable

Parts to Make:
5- Tube Head
7- Print Head
10- Feed Connection



Welder

Design Process:

Two large competitors in the welding community are Lincoln Electric and Miller Electric:

- Lincoln Electric is often preferred for Stick Welding
- Miller Electric is often preferred for MIG and TIG Welding
- Both companies are comparable in price for the parts we need to purchase
- Both companies have a long history in providing quality welders and parts

Because Miller Electric is preferred by professionals for MIG welding, makes quality parts, and is about the same cost as Lincoln Electric, we will source all necessary parts from Miller Electric. Buying from one company also ensures that all parts will fit correctly

Integration

* Primarily 2nd Semester
  * Print Head – Manufacture in ME Machine Shop
  * Enclosure – Extruded Aluminum
  * Fume Extraction – Fans, Outlets
  * Wire Cutter Assembly
  * Sensors – Infrared Thermometers and Proximity

Potential Issues

* Heat
* Safety
* Power – Circuit Breaker
* Resolution
* Cost